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ENVIRONMENTAL PROFILES FOR RELIABILITY TESTING OF NAVY ELECTRON--ETC(U)
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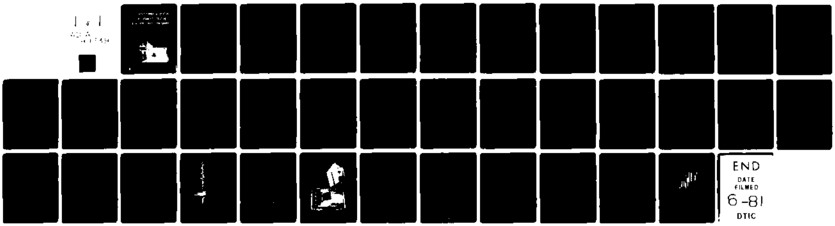

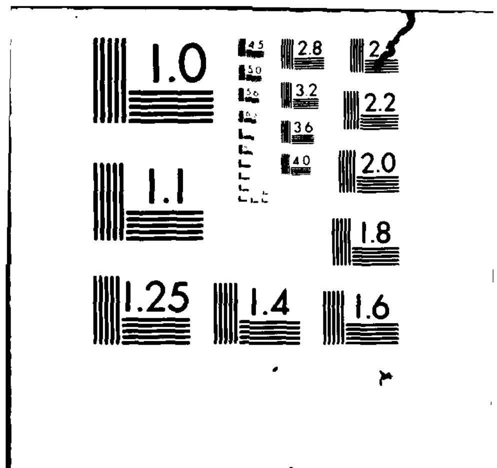

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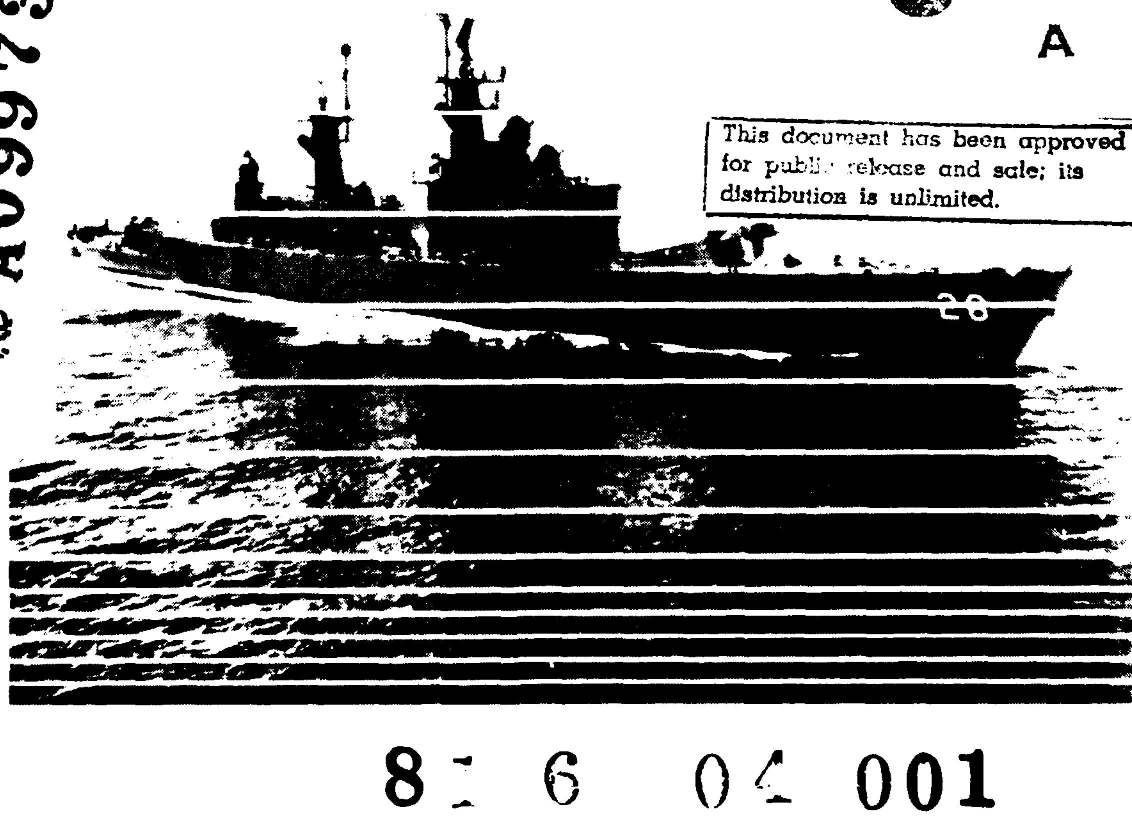

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PORT HUENEME, CALIFORNIA 93043

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ABSTRACT

This is a status report on the Environmental Profiles Program sponsored by the Naval Research Laboratory. The objective of the program is to provide statistical distributions of shipboard environments, based on extensive measurements in the fleet, for use in design of tests for shipboard weapon system equipments.

FOREWORD

In November 1977, Naval Research Laboratory (NRL) tasked Naval Ship Weapon Systems Engineering Station (NSWSES) to undertake a program to obtain shock/vibration data from newer ship classes for use in developing statistical environmental profiles. Temperature and humidity data was also to be provided. The data obtained is to support the NRL environmental research study for the Joint Technical Coordinating Group on Reliability, Availability, and Maintainability (JTCG-RAM).

This program was integrated with the Shipboard Environmental Program (SEP), an on-going study tasked to NSWSES by Commander, Naval Sea Systems Command (NAVSEA) in February 1977. In this study, all known Navy environmental reports, were analyzed and were found to be deficient in time base data; as a result, a major effort was initiated to obtain additional data. The data will be used to develop statistical distributions of shipboard environments suitable for realistic planning of tests for weapon system equipments. This is the first annual report of progress related to the NRL task.

This work is authorized by Naval Research Laboratory Work Request Number N00173-78-WR-80046 of 4 November 1977.

CONTENTS

I. INTRODUCTION AND SUMMARY

There is concern that environmental tests of new shipboard weapon system equipments are not representative of the operational service environment. Many test specifications currently in use are based on obsolete environmental data from ships no longer representative of the fleet. These test specifications often require short-duration testing only under "worst-case" conditions, which may be unrealistically high or may actually impose less stress on the equipment than longer-duration testing over a range of conditions representative of the actual fleet environment. In addition, some test specifications are for test conditions which are generalized for the fleet, and not applicable for the particular ship installations.

In 1975, the Shipboard Environmental Program (SEP) was initiated by the Naval Sea Systems Command (NAVSEA), Code 06G2, to correct this situation. NSWSES was tasked to support NAVSEA in February 1977. In November 1977, Naval Research Laboratory (NRL) requested that their need to obtain shock/vibration data be integrated with the on-going SEP study.

A. Purpose

With commencement of environmental studies at NSWSES early in 1977, long-term objectives of the program were identified:

1. Provide statistics which describe the frequency distributions of all environments that affect reliability, for all existing and future shipboard locations containing equipments of Navy Combat System.

2. Provide a basis for and assist in use of these statistics in plans for development and acceptance tests of new Navy equipments.

3. Assist in efforts to improve the conglomerate of military environmental test specifications.

B. Scope

Initially, the ships and equipments of concern are those involving surface missile systems, because of NSWSES direct responsibilities for and knowledge of these systems. Ultimately, all surface ship combat systems under cognizance of NAVSEA are to be included.

The environmental study will include but not be limited to temperature, humidity, vibration, shock, electro-magnetic interference, and voltage and frequency fluctuations of shipboard power systems.

C. Summary

The over-all status of the program as of November 1978 is as follows.

1. All published environmental reports known to exist have been collected and sorted by environment and location of measurement. (Other reports will be added to the index as they become available.)

2. Analysis of all source documents has been completed to determine adequacy for statistical display.

3. Design of vibration and shock measurement instruments has been completed. A prototype recorder was completed in October 1978. Build-up of three instruments is now in progress. The recorders are expected to be completed and ready for use early in 1979.

4. Temperature and humidity instruments have been procured, recordings have been obtained aboard SMS ships, and statistical distributions have been derived.

5. Close coordination is being accomplished with all other agencies involved in Navy environment studies, to ensure correlation of efforts without duplication.

6. Instrumentation to monitor and measure voltage and frequency of ship power has been procured.

D. Participants

Personnel engaged on the NAVSEA and NRL programs are as follows.

NAVSEA

Henry Itkin, Code 06G1

NOSC*

Dick Chalmers, Code 9131

NUSC*

Gary Lipset, Code 411

NRL*

Lionel Moskowitz, Code 5326
Don Hemenway, Code 5325

NWC/CL*

Howard Schafer, Code 6212

NSWSES

Roger Muir, Code 0740
Roman Kruchowy, Code 0740
Ted Rubin, Code 0703C
Horton Perry, Code 6303C

NAVELEX*

Bill Wallace, Code 470

NAVMAT

Ken LaSala, Code 08E51

TRACOR, Inc.*

Bob Feltes

*NRL Study Only

II. TECHNICAL DISCUSSION

This section describes the program and progress in detail.

A. General Approach

The objectives of the program as specified by NRL are to obtain shock/vibration data from newer ship classes and develop statistical environmental profiles. To achieve this end major tasks were to be accomplished sequentially to prevent repetition of work. The following tasks were performed as specified in the overall program plan by NRL.

1. Collection, Sorting and Listing of Existing Data. The first task was to collect, sort and list reports related to the shock/vibration data aboard ships. The result of this collection effort was presented in the "Environmental Life Cycle Program, Semi-Annual Summary;" January 1978, Appendixes A and B.

2. Analysis of Source Documents. To determine whether the data previously obtained contained statistical merit, thorough examination of the documents collected was made. The result of the analysis indicated that there is essentially no useful vibration and shock data which can be used to provide statistical evaluation of environmental conditions aboard ship. A similar conclusion was reached with regard to available temperature/humidity data. Therefore, the major effort is now the accumulation of new data.

3. Obtaining Necessary Recorders. A shock and vibration measurement and recording system was designed to meet data requirements of NRL. The system technical requirements are as follows.

a. The component parts shall be packaged so that no single packaged portion of the system shall exceed 40 pounds. The system shall be packaged in a maximum of three weather-tight cases equipped with handles

for ease of carrying. The volume of each case shall not exceed that of a typical two-suiter suitcase and shall provide isolation of the measurement devices and circuits from the shipboard environment (5Hz - 50Hz and a maximum of 10 gs).

b. The system shall be capable or recording the output of commercially available vibration and/or shock sensors. The range of recording capability shall be 2Hz - 200Hz frequency and 0g - 30g acceleration. with a resolution of 0.01g.

c. The system shall record the sensor's analog signal without appreciable distortion ($\pm 1\%$) or degradation of signal and signal content when sensors are mounted up to 250 feet from the recording center. The recording media shall be tape, either cassette or reel; an end-of-tape alarm device and automatic drive power shut-off shall be incorporated.

d. The system shall be capable of recording sensor data continuously and intermittently when triggered by the sensor signal exceeding a predetermined level (i.e., record for two minutes maximum when vibration exceeds 0.1g). Additionally, the system shall be capable of recording sensor data for a preset interval of time at present recording intervals for a 30-day period (i.e., once every four hours for two minutes).

e. The system shall be capable of recording six channels of sensor data plus one channel of time which shall be capable of being set to a time selected by the test engineer. Multiplexing may be incorporated at the discretion of the system supplier. Current state-of-the-art electronic techniques shall be employed in achieving ease and simplicity of operation while maintaining high quality recording.

f. The sensors employed and furnished with the system shall be capable of being mounted on standard transducer mounting blocks via a

tapped 10-32 UNF-2B thread in the sensor bottom. A calibration certificate shall be supplied with each transducer furnished. The sensor resonance shall be no less than 30KHz mounted. One sensor shall be supplied for each recording channel excepting the dedicated time channel.

g. The system shall be capable of operating from ship's power (110 - 120 VAC, 60Hz) unattended for approximately 30 days without maintenance and calibration (if possible) or be capable of being easily calibrated without external devices required. Loss of power during the operating period may occur with attendant loss of data recording; however, the system shall be capable of resuming data-taking without degradation.

h. Each system shall be delivered complete with operating instructions, parts identification, circuit schematic with nominal operating values, and maintenance instructions. Special tools, if any, shall be delivered with each system furnished.

4. General Description of SUDS

The requirements were achieved by a NSWSES prototype design called the Shipboard Unattended Digital System (SUDS), a portable, high-resolution, multi-channel data acquisition and recording system (Figure 1). Designed for unattended operation for extended periods of time, using ship's 120V, 60Hz, 10 watts normal (100 watts maximum) power, the prototype consists of a recorder, a digital data interface device, and a remote data unit, with package volumes of 1.4 cu ft., 1.3 cu ft. and 0.09 cu ft., respectively. Digital transmission of data from the RDU will allow data collection under adverse RFI/EMI conditions without alteration or interruption of normal ship's electronics systems. Detailed specification of system components are given in Table I. Schematic description of the prototype system is shown in Figures 2, 3, and 4.

a. Remote Data Unit

The Remote Data Unit (RDU) is a separate weather-tight enclosure approximately 5" wide x 10" long x 8" high. It contains the

transducer excitation current circuitry, the multiplexing circuitry, the analog to digital circuitry, and the sample/hold circuitry. Each RDU has the capability of accommodating up to 16 transducer outputs; however, only eight channels will be used in the gathering of vibration data for SEP.

BNC series connectors are used with RG-58 cables to interconnect the RDU to the main module which contains the digital data recorder, data processors, and data output section of the SUDS.

b. Data Inputs

The analog input channels accept 0 to ± 10 volt signals, have input impedance greater than 10 M Ω and are over-voltage protected to ± 100 volts. All channels are compatible with 815A5 Piezotron accelerometer which may be subject to ± 30g. The dynamic range of the system is 72.2 db. One BNC connector is used for each of the RDU analog input channels. A switch is employed with each channel to select between high impedance voltage input and the accelerometer charge amplifier input.

c. Signal Conditioning

The system signal conditioning consists of an amplifier followed by a 6-pole, 400 Hz Butterworth low pass filter for each input channel. The filtered data is multiplexed by an analog switch to permit sequential sampling of multiplexed channels by a 12 bit A/D converter. The minimum sampling rate of each channel is 2.0 KHZ. The analog multiplexer maintains 70 to 80 db isolation between adjacent channels to prevent cross-talk distortion. Super commutation features are incorporated to increase sampling rates on selected channels and allow handling of high-frequency data.

The total signal distortion permitted by first analog multiplexing, digital multiplexing, recording, demultiplexing and D/A conversion is 0.1%.

d. Recorder

The digital data recorder has the capability of recording 64 channels of data continuously for one hour. The unattended operational mode employed when installed aboard ship is programmed for 30 to 45 seconds of data gathering at preset intervals, normally every four hours.

Additionally, special circuits detect transients, such as those caused by gun shock, on any of the input channels. The threshold for these circuits is adjustable over the entire input range. Exceeding the threshold will initiate a 45-second or longer recording period.

The SUDS has both a Digital and Analog output. The Digital output consists of an 18-bit buffered register containing the 12-bit word and 6-bit address. The digital output is to be TTL compatible and is intended for use with micro processors and computers.

The analog output consists of separate sample-and-hold circuits. The output of each can be compared with the corresponding input signal to permit data monitoring and evaluation on a real time basis. The output also contains suitable calibration information. The analog outputs are to be available to eight separate BNC connectors, and the channels for these connectors are panel selectable.

e. Power Requirement

The basic power requirement is 115 VAC ± 10%, 60 Hz, 5A maximum.

B. Shipboard Tests

The SUDS was installed aboard a DDG-2 Class ship in mid September 1978 to gather six channels of vibration data while underway, for proof testing. The gear was installed in the Sonar Equipment Room, rather than the TARTAR Equipment Room which was due to the presence of a Ship

Qualification Assistance Team (SQAT). The data taken (Figure 5) revealed several unforeseen problems within the equipment which required minor design to resolve. Problems with frequency fluctuations of ship's 120 volt power caused the recorder motor drive to vary in speed. The problem was solved by incorporating a 50 Hz circuit in the recorder which allowed the motor to operate normally even in the presence of $\pm$ 6 Hz fluctuation in the ship's power.

The record problem involved the presence of 60 Hz harmonics in the data train. The gain on the transducer had been set at 10g as opposed to 0.1g, thus, the 60 Hz harmonics from the power lines bundled in with data lines were quite obvious on the traces. The problem will diminish when the transducer gain is properly set and will disappear in follow-on systems by separation of power lines from data lines.

Delay of prototype testing was incurred because the supplier of the Digital Data Interface went out of business. This required a design modification of the system using substitute components.

The SUDS was again placed aboard USS ROBISON (DDG-12) in January 1979. Vibration data was taken while the ship was undergoing qualification trials.

Three accelerometers were mounted to the main structural members supporting a portion of the TARTAR weapon system consoles. Vibration/shock measurements were made during normal cruise conditions and during gunfire qualification tests.

The taped data was subsequently sent to NOSC for Fast Fourier Transform and Power Spectral Density processing. The Power Spectral Density results were stored on magnetic tape for further computer processing and statistical modeling.

A typical Power Spectral Density plot for each of the accelerometer is shown in Figures 6 through 8. These Figures indicate normal cruise vibration conditions aboard ROBISON. The vertical axis is graduated from 0 to 50 decibles, with the 0 db reference value indicated along the vertical axis (i.e. 0 db =.01999 G/SQRT(Hz) in Figure 6). An RMS acceleration level is also provided, and is denoted as GRMS on the figure.

Shock measurements were made during gunfire qualification tests. A time vs acceleration trace is shown in Figure 9 during one of the several gunfire conditions. This portion of the shock trace was submitted for Fast Fourier Transform analysis. The result of this analysis is shown in Figure 10. A 0.01 g peak at 20 Hz is predominantly visible in the spectrum, which is considerably below the 0.8 g test level specified by MIL-STD-167.

C. Ship Induced Environemnts

The shipboard environment program will include a study of all significant factors affecting the performance of a ship missile system. Many of these environmental conditions are induced during normal ship operation.

1. Shock and Vibration. Shock and vibration is transmitted to ship weapon areas via ship structure. These effects may be initiated by one of these three predominant sources:

a. Propulsion machinery (shaft, propellor)

b. Ancillary rotating machinery (pumps, fans) and

c. Hydrodynamic forces (sea conditions)

The long-term effect creates vibrational fatigue and, hence, reduces the reliability of equipment in these areas.

2. Voltage/Frequency Fluctuations. Previous studies at NSWSES indicated a correlation between power line voltage fluctuation and equipment failure. Large voltage and frequency variations would exceed equipment specifications, thereby degrading equipment performance or causing electronic component failure. Two stand-alone instruments have been procured to monitor and measure voltage/frequency fluctuations. A photograph and specifications of the unit are shown in Figure 11 and Figure 12. A trial test of the unit was performed aboard ROBISON during gunfire qualification trials in January 1978. The line disturbance analyzer was attached to the 115V, 60 HZ ship power line for approximately 24 hours. During that interval, the following power line conditions were observed.

Average Voltage:	116V	
Low Average:	112V	
High Average:	117	
Sag:	109V	22 times
Surge:	115V	2 times
Impulse:	64V	3 times
Frequency Range:	59.5 - 60.7 Hz	

Following this test, the analyzer was connected to the 115V, 400 Hz, 3-phase power line for an additional 24 hours. The following line conditions were observed.

Phase A Average:	120V		Phase B Average:	116V
Phase A Sag	115 V	17 times	Phase C Average:	120V

No impulse voltages were observed during this period.

3. Electro-magnetic Interference. It has been found that normal radar operation leaks micro-wave energy into various ship weapon spaces. This high electro-magnetic energy induces interference in the electronic systems. Future plans call for monitoring the level of radiation to determine the degree of shielding required to suppress electron-magnetic interference.

D. Data Utilization

The following "spin-offs" were provided from T/H survey.

1. Copies of data were forwarded to NAVSEACENPAC San Diego for use in studies of shipboard air conditioning requirements.

2. Environmental data from DDG barbettes with large bulkhead areas exposed to the weather were provided to assist in TARTAR equipment failure investigations.

3. The presence of water in air-conditioned equipment compartments was detected from T/RH data, revealing a previously unsuspected failure mode.

4. The practice of lowering thermostat settings in air-conditioned areas was shown to increase the possibility of condensation in equipment cabinets after a day/night/day cycle. Collection of data in tropic zones may show this to be a serious problem.

5. Based on a CONAR which reported excessive temperature in a specified missile area, an investigation was made of T/RH data from similar class ships. The analysis confirmed and quantified the reported excessive temperature condition.

6. A complete T/RH profile was made of DDG-2 Class ships for application to the TARTAR Radar Data Processor procurement. The results are presented in Figures 13 and 14.

7. A table of absolute humidity with relative humidity and temperature as variables was generated to facilitate correlation of environmental data. The table was based on the following equation for absolute humidity at standard barometric pressure: $A = \frac{0.6228\ p\ R}{29.92 - p}$

where:

R = percent relative humidity

A = absolute humidity, pounds of water per pound of dry air

P = vapor pressure at T, inches of mercury (Keenan and Kay Tables)

T = dry air temperature, degrees F

$$0.6228 = \frac{\text{mol weight of water}}{\text{Equiv. mol weight of air}}$$

29.92 = standard atmospheric pressure, inches of mercury relative

The table provides the absolute humidity for temperature and humidity ranges of 35° - 140°F, and 100% - 61%, respectively. The table was supplied in Appendix C of the "Shipboard Environmental Program Semi-Annual Summary," July 1978.

E. Test Plans

The ultimate objective of this program is to prescribe test plans which realistically expose developing electronic hardware to representative environmental conditions. As an example of this, based on temperature and humidity data from six ships during 1978 (Figure 15) a typical acceptance test plan was developed (Figure 16). A qualification test plan can be similarly determined by examining the statistical distribution of temperature extremes in a specified weapon area.

F. Schedule

Figure 17 shows the present schedule of major tasks. V/S measurements will be performed on ships on a maximum utilization basis as each of the three final SUDS units becomes available. Due to the unanticipated problems during the development of the prototype, the schedule has slipped about six months.

TABLE I

SYSTEM SUB-COMPONENTS SPECIFICATIONS

A/D CONVERTER:

Manufacturer - DATEL Systems Inc.
Model No. - ADC-HF 12BMR
Resolution - 12 Bits
Accuracy - 0.01·/.
Conversion Time - 2 msec
Output Coding - Binary, 2s complement
Input Range - 0 to 5V, + 10V, ±25V, ±5V, ±10V
Linearity - 1/2 LSB
Temp Range - 25 to 85 (°C)
Gain TEMPCO - 25 ppm/°C
Power Requirements - ±15V, + 5V

ANALOG MULTIPLEXER:

Manufacturer - DATEL Systems Inc.
Model No. - MX-808
No. of Channels - 8
Type Input - Single Ended
Input Voltage Range - ±15V
Input Overvoltage, MAX - ±35V
Channel on Resistance - 1.5K
Channel off Resistance - 200 MEG OHMS
Channel off Leakage - 30 pA
Channel Addressing - 3 bit code
Address Logic Compatibility - DTL/TTL/CMOS
Transfer Accuracy - .01·/.
Crosstalk - -86dB
Turn on Time - 500 msec
Turn off Time - 300 msec
Power Requirements - ±15V
Operating TEMP Range - 0 to 70°C

SAMPLE-HOLD:

Manufacturer - DATEL Systems Inc.
Model No. - SHM-IC
Accuracy - 0.1·/.
Acquisition Time - 5 msec
Aperture Delay - 50 msec
Voltage Range - ± 10V
Gain - ±1.0D

TABLE I (Continued)

Band Width - 2 MHZ
Hold-Mode Droop - 50MV/msec
TEMPCO - 20MV/°C
Power Requirement - ±15V
TEMP Range - 0 to 70 (°C)

DATA CONVERTER:

Manufacturer - DATEL Systems Inc.
Model No. - DAC-DG12B1
Resolution - 12 BITS
Accuracy - 0.1%
Output - Voltage
Settling Time - 500 msec
Linearity - 1/2 LSB
Input Coding - Binary
Output Ranges - 10V, ±5, ±10V
Gain TEMPCO - 35ppm/°C
Power Requirements - ±15V

ACCELEROMETER:

Manufacturer - Sunstrand Data Control, Inc. (PIEZUTRON)
Model No. - 815A5
Range - ±50 g
Electrical Noise, independent of cable length - 0.002g rms
Reference Voltage Sensitivity, nom. - 50 mV/g
Resonant Frequency - 30± kHZ
Time Constant, nom - 0.5 sec
Low Frequency Response down nom 5% at - 1 Hz
High Frequency Response up 5% ±2% at - 5000 Hz
Amplitude Linearity - 1 ±%
Transverse Sensitivity max - 5%
Temperature Sensitivity Shift - 0.025%/°F
Vibration Limit, axial - ±500g
transverse - ±250g
Shock Limit, 1 ins pulse width - 500g
Temperature Range - -65 to +250°F
Output Voltage - ±2.5V
Output Current, min. - 2 mA

SHIPBOARD ENVIRONMENTAL PROGRAM

SHIPBOARD UNATTENDED DIGITAL SYSTEM
("SUDS")

(UP TO 30 CHANNELS CAPABILITY)

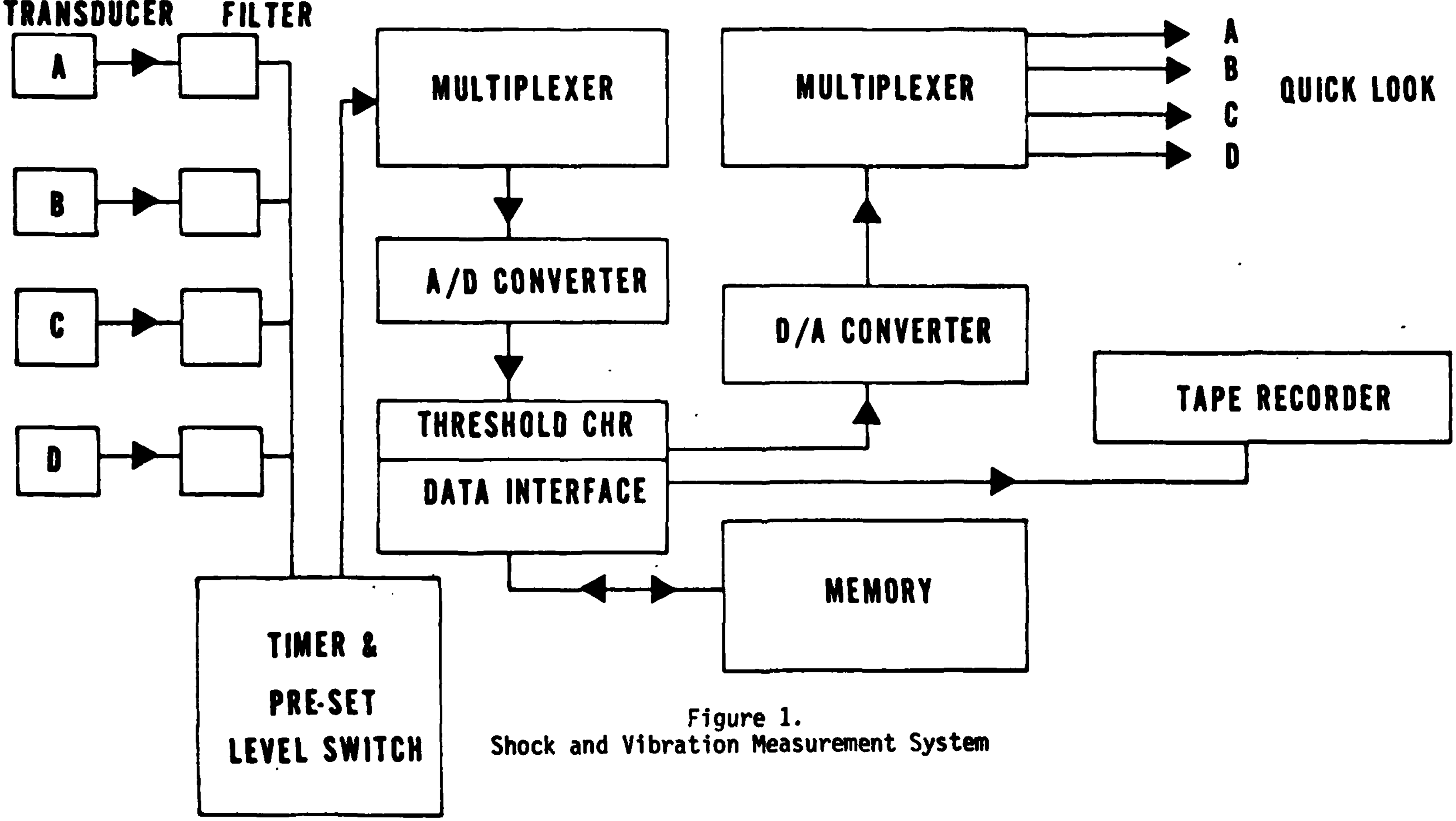


Figure 1.
Shock and Vibration Measurement System

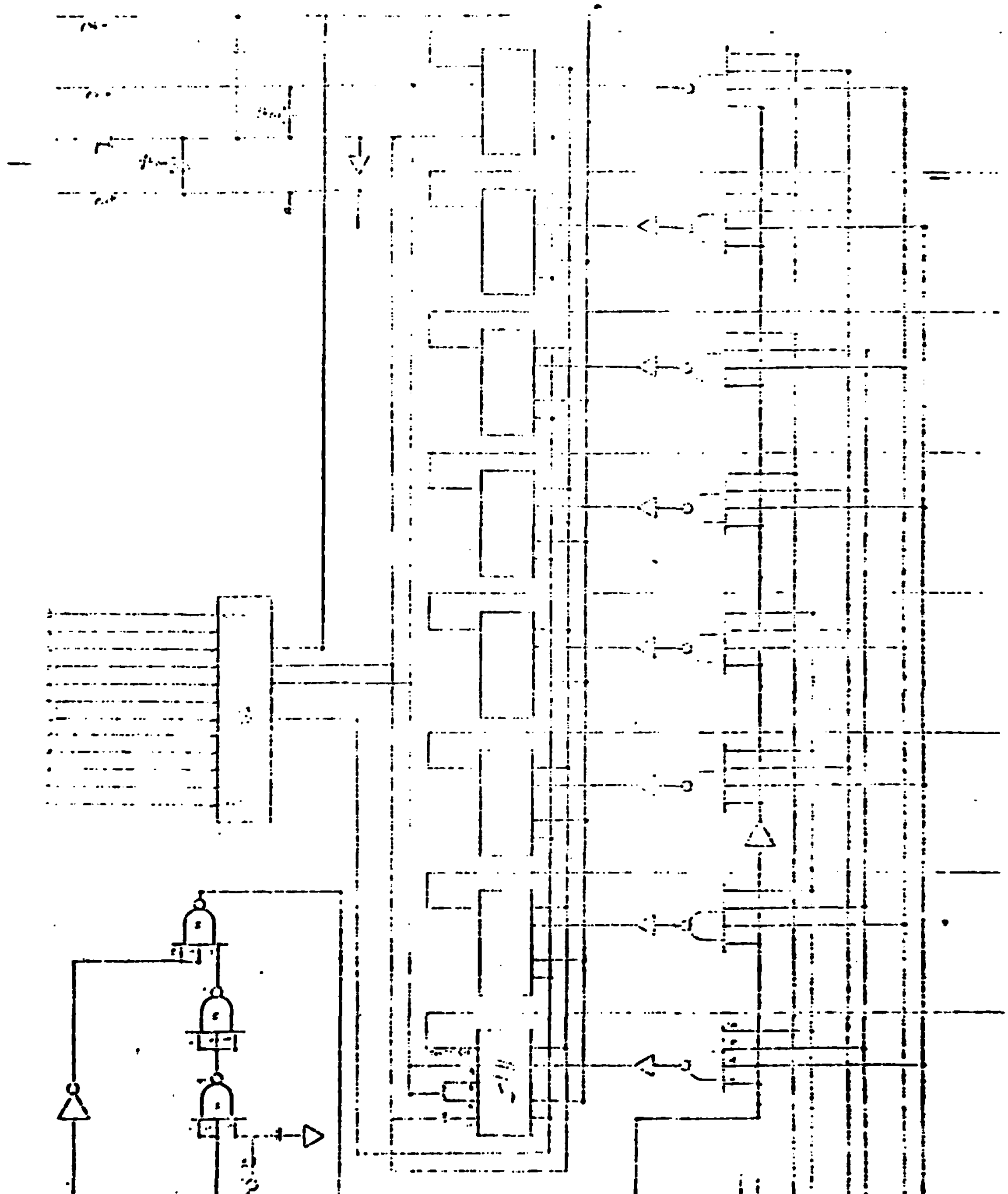


Figure 2.
Prototype Circuit - Remote Data Unit

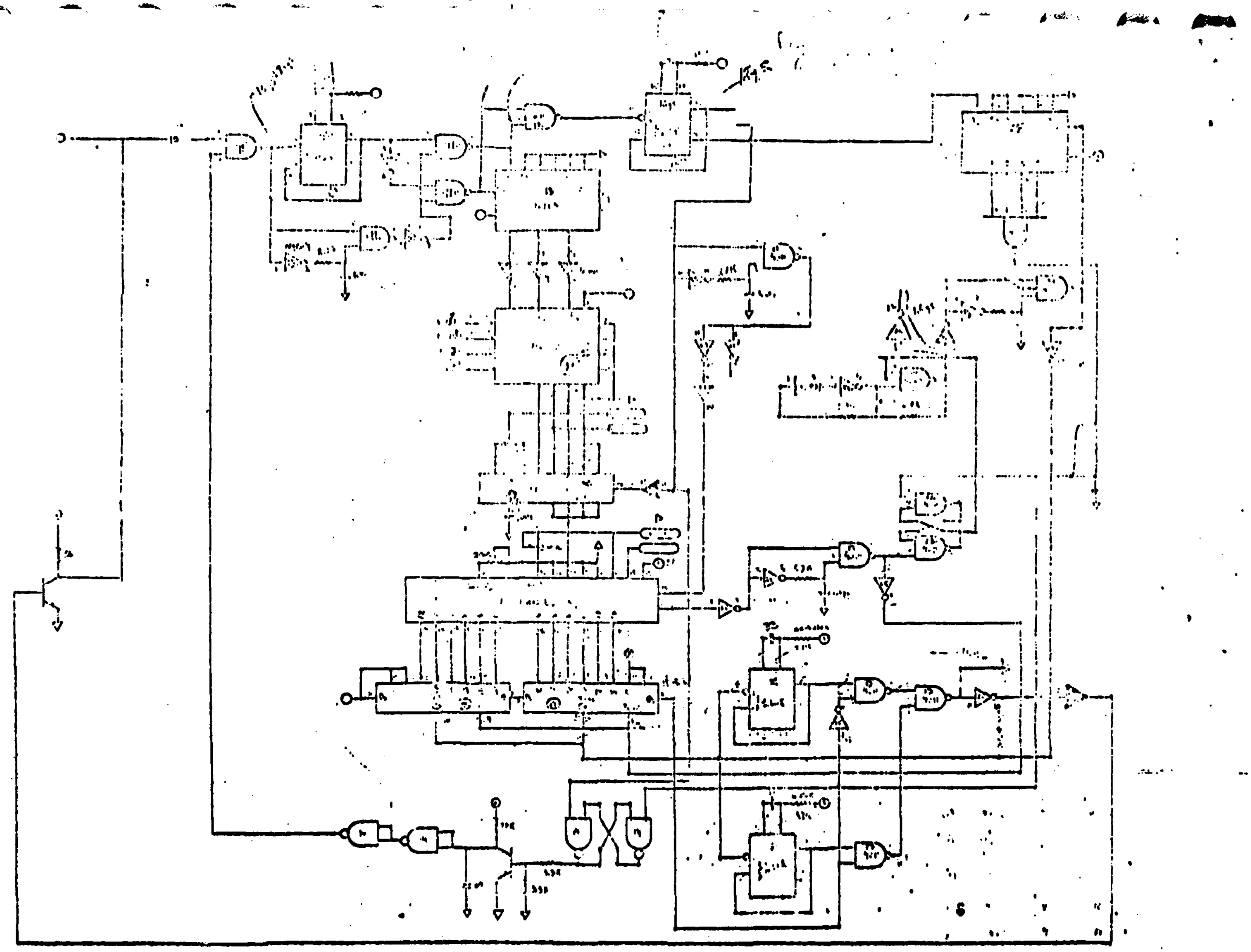


Figure 3.
Prototype Circuit - Digital Data Interface Unit

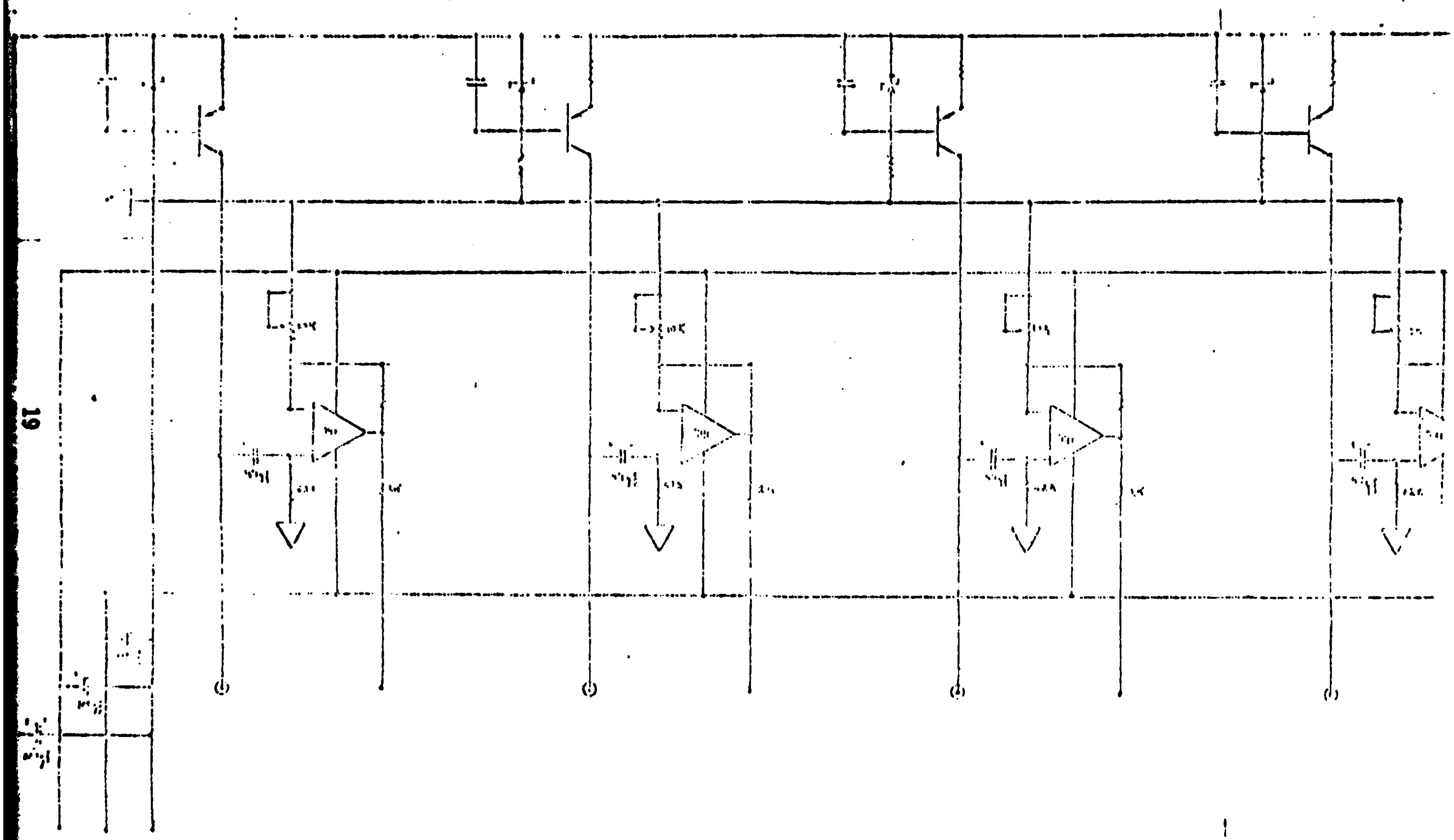


Figure 4.
Prototype Circuit - Transducer Excitation

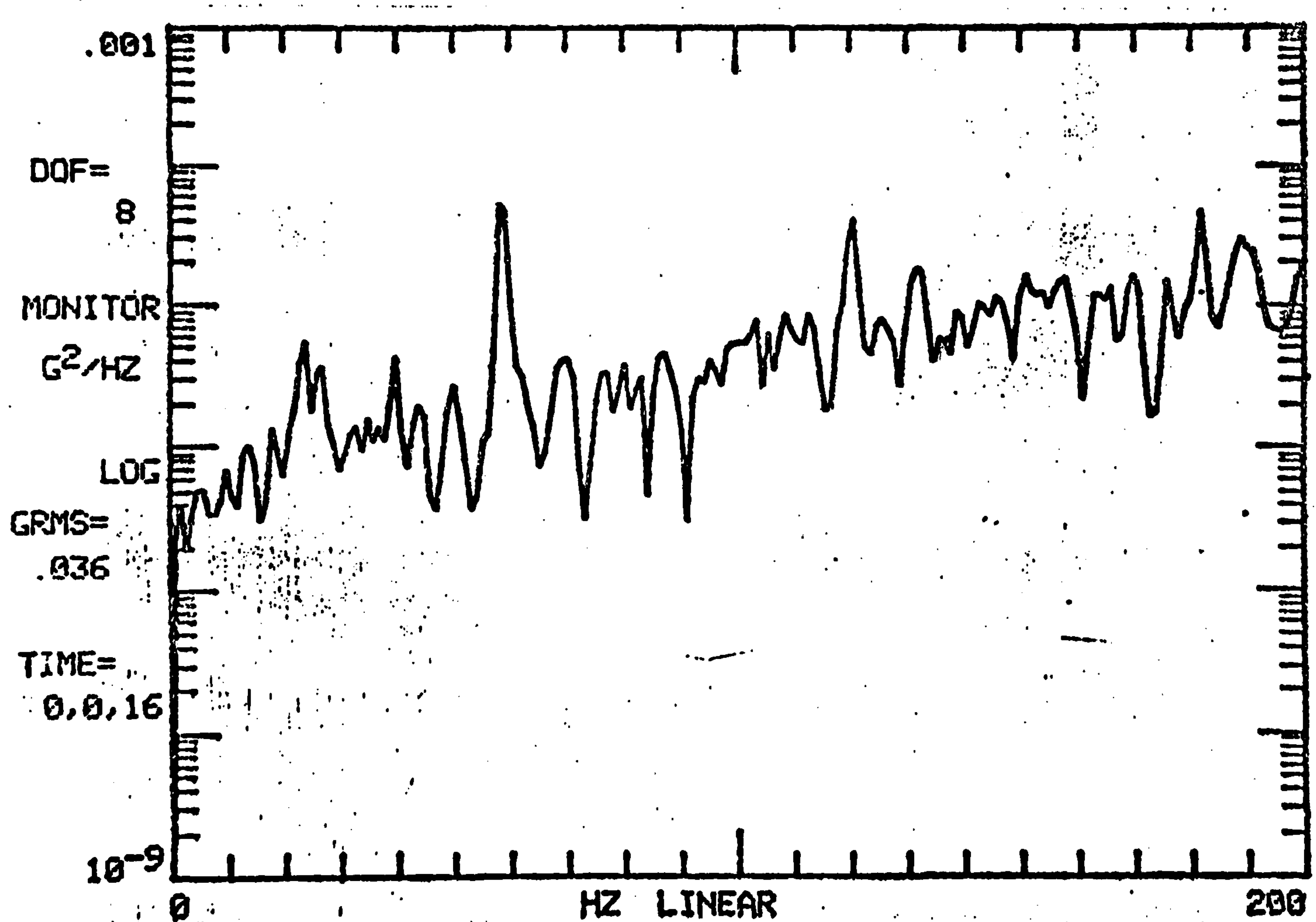


Figure 5.
Power Spectral Density Plot (Vibration)
USS H. B. WILSON (DDG-7)

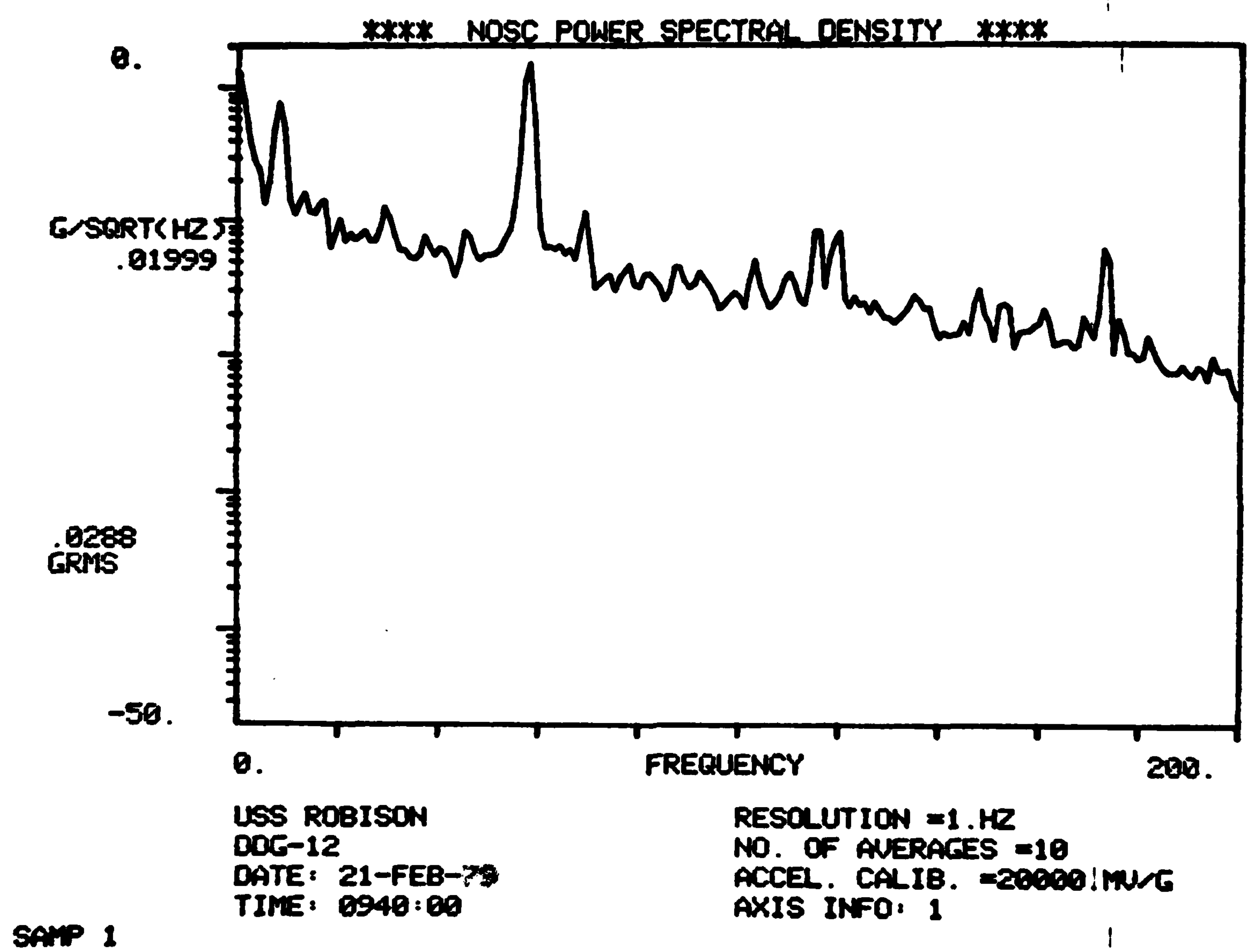


Figure 6. Power Spectral Density (Channel 1)

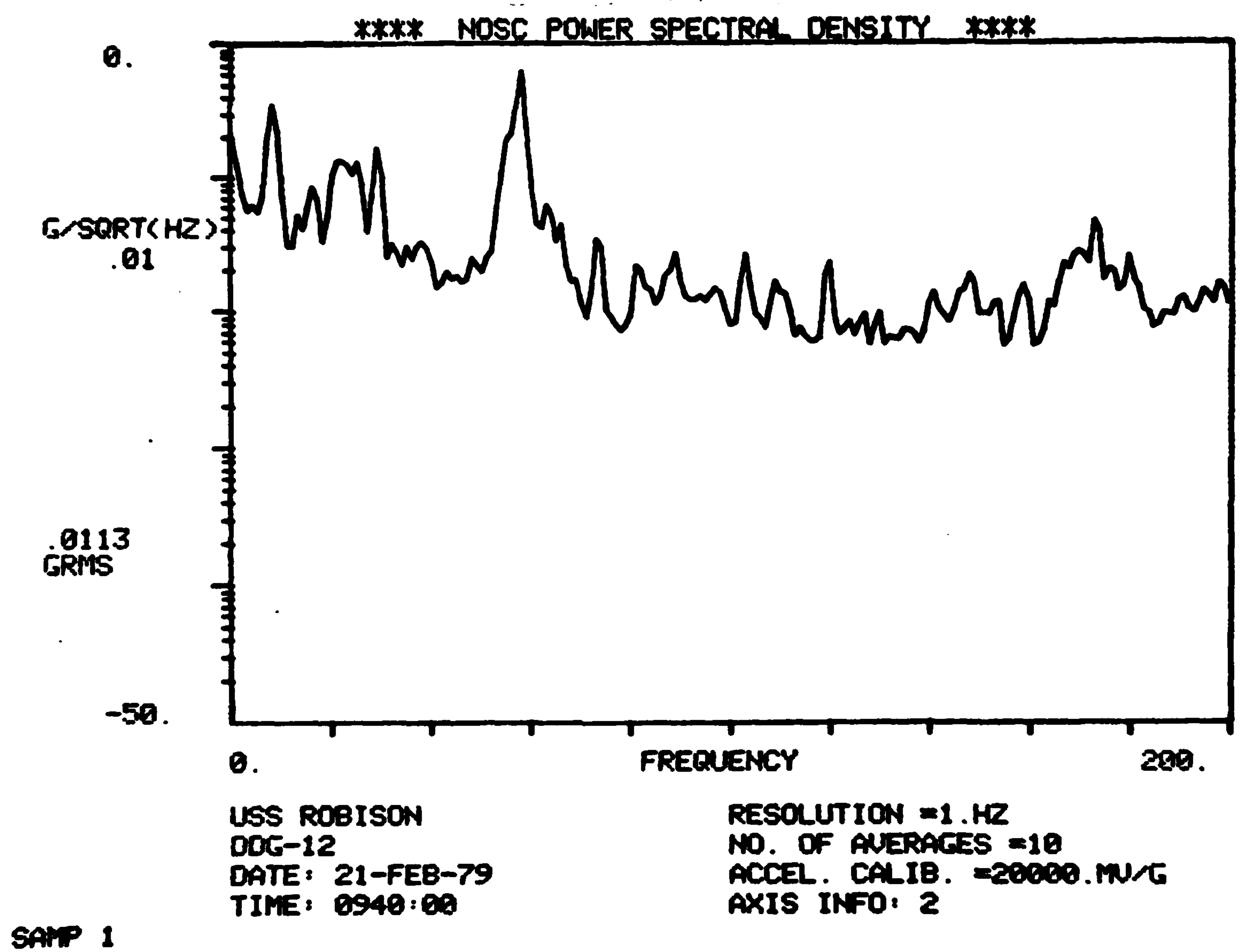


Figure 7. Power Spectral Density (Channel 2)

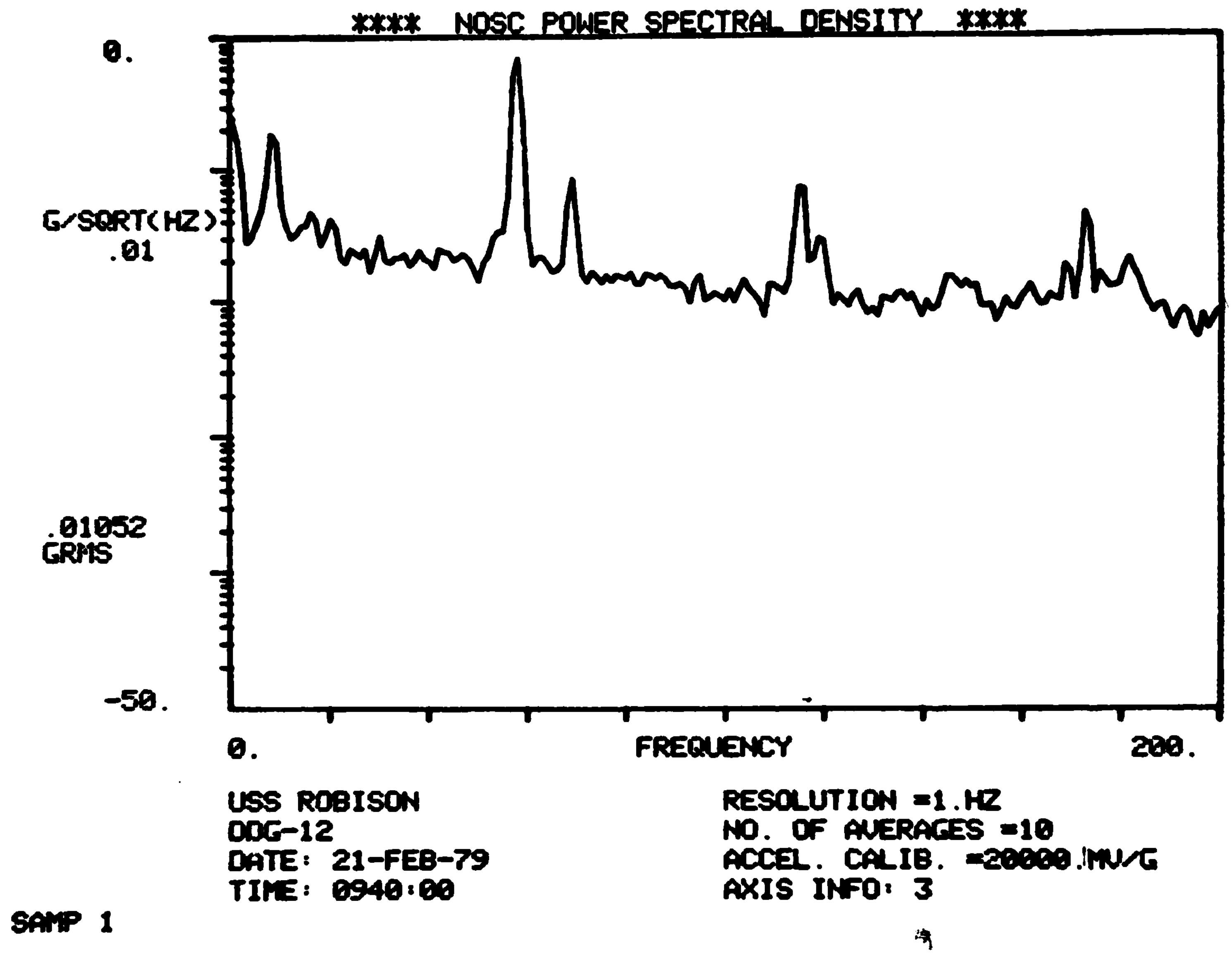


Figure 8. Power Spectral Density (Channel [illegible])

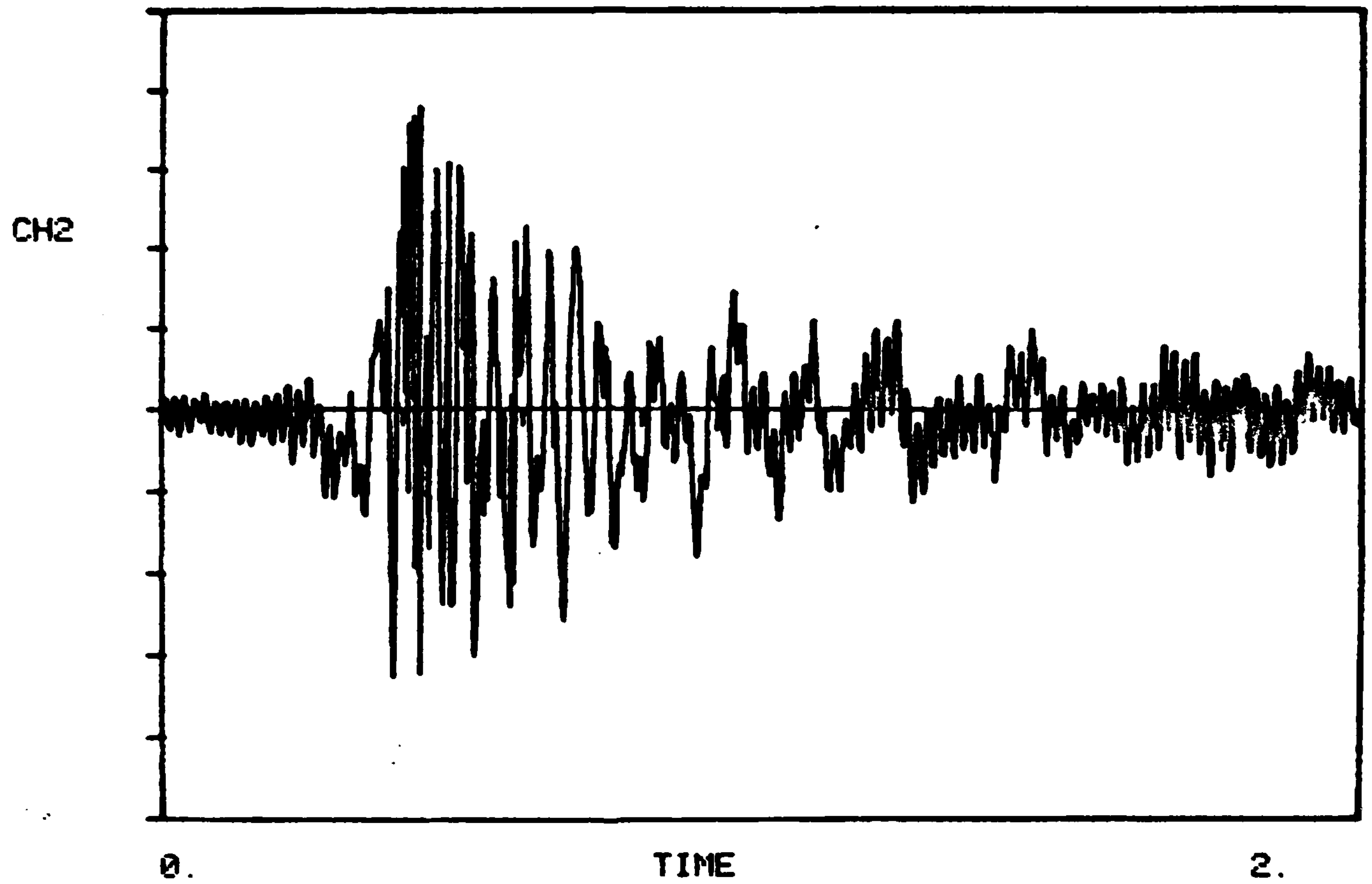
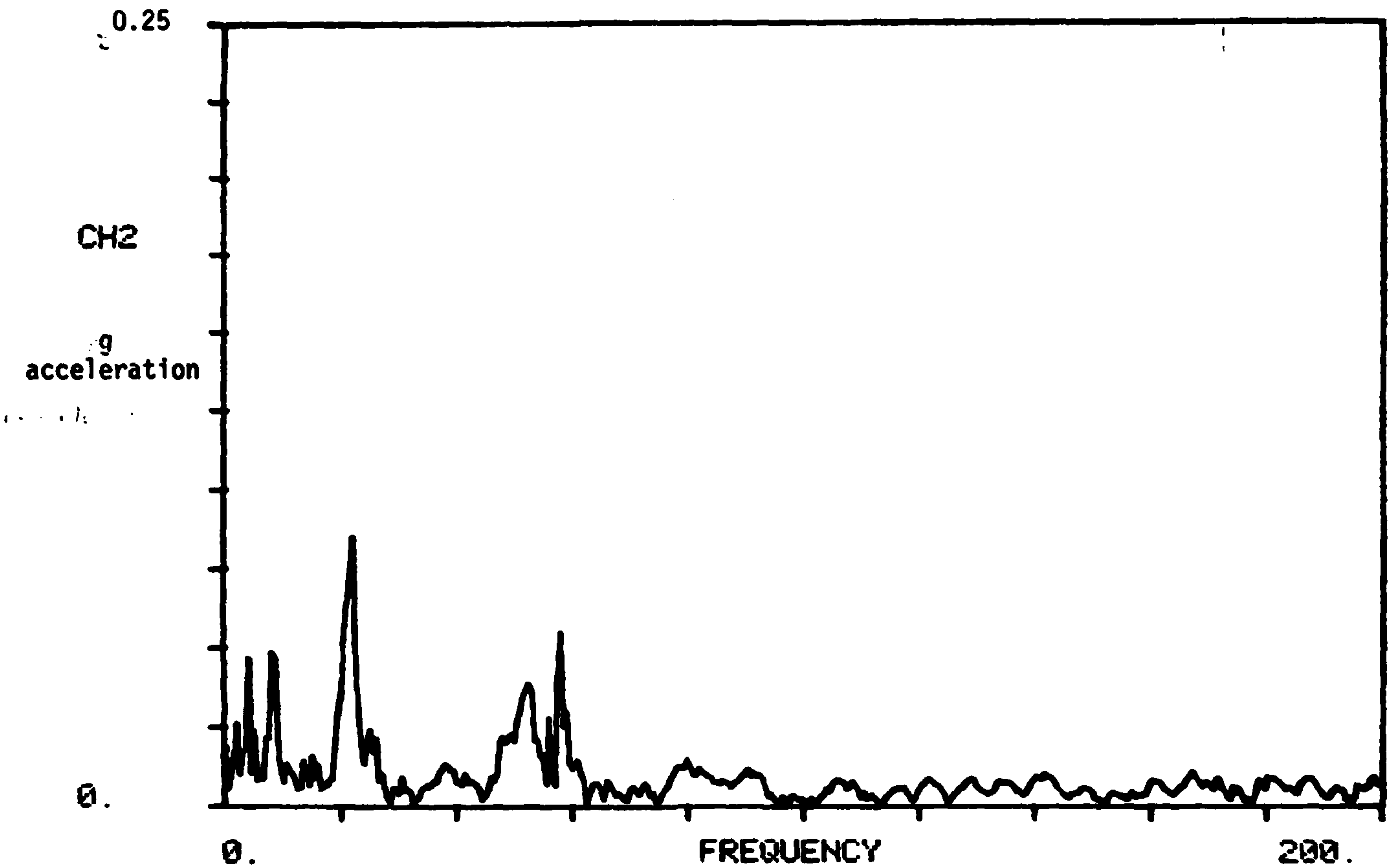


Figure 9. Time History of Acceleration Produced by Gunfire



gun #2

Figure 10. Fast Fourier Transform of Gunfire Induced Vibration/Shock

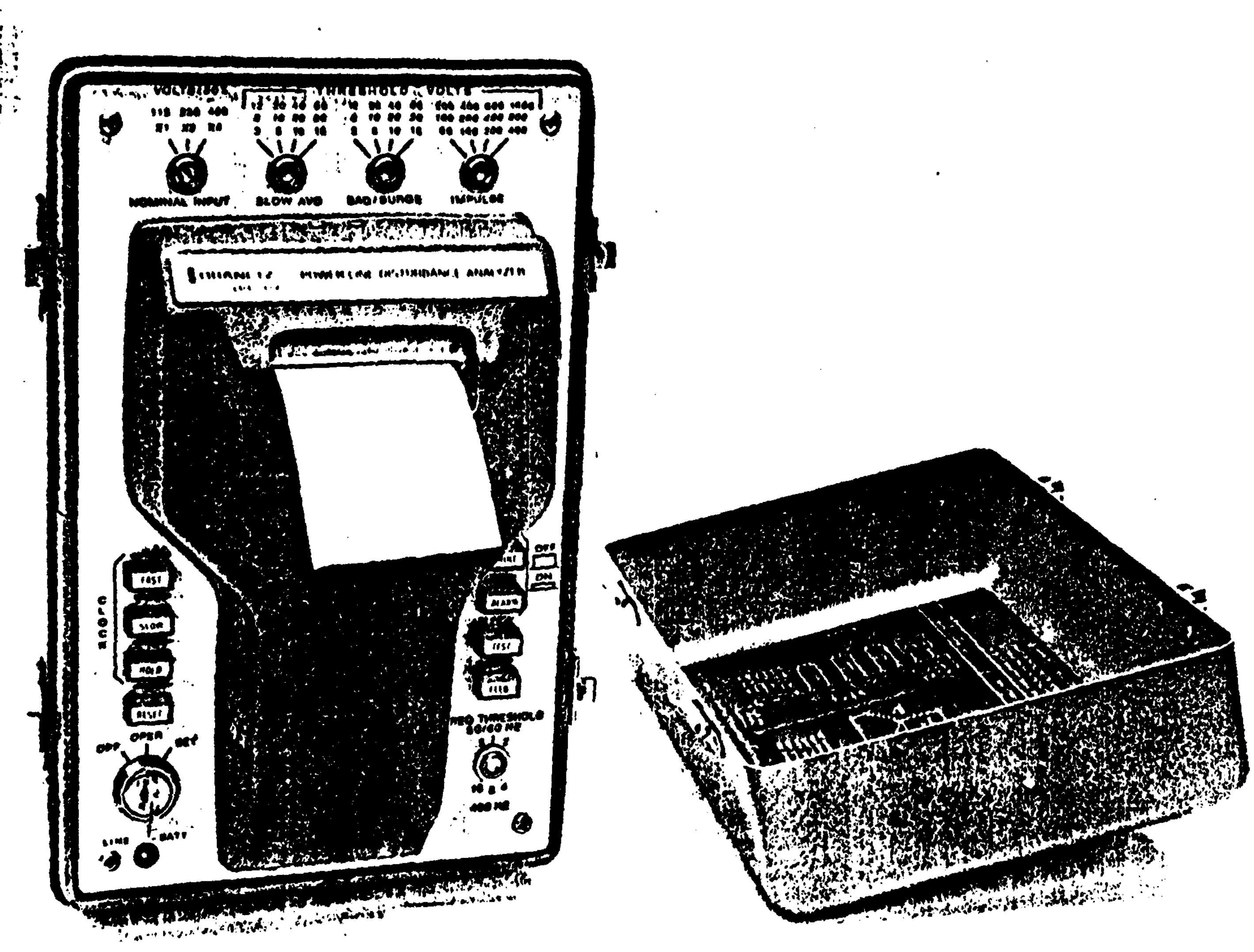


Figure 11. Series 606 Power-Line Disturbance Analyzer

Specifications for Power-Line Disturbance Analyzers

MONITOR MODES

Slow Averaging: Slow steady-state changes in line-voltage inputs (approx. time constant: 5 seconds).

Sag/Surge: Cycle-to-Cycle changes in RMS line-voltage inputs.

Impulse: Peak reading of impulse (after filtering out line voltage waveform) having a duration between 0.5 and 800µsec.

Accumulated Count: Summary of disturbance information stored in instrument memory. (Printed out automatically at midnight covering previous 24 hours, or on command by panel push-button.)

INPUTS MONITORED (connections on rear)

Model 606-1: Single transformer-isolated input, 2-wire, 50 or 60 Hz.

Model 606-3: Three transformer-isolated inputs, 3 pairs 2-wire, 50 or 60 Hz. (Can be 3-phase Wye or Delta).

MONITOR INPUT VOLTAGE RANGES

(Selectable by front panel switch)

Range Designation (Color Coded)	Nominal Input (V_{RMS})*	Maximum Impulse† ($V_{0\text{-}pk}$)	Input Impedance
X1	115	1000	100kΩ
X2	230	2000	200kΩ
X4	460	4000	400kΩ

THRESHOLD VOLTAGE (Selectable by front panel switches)

	For "X1" Input Range	For "X2" Input Range	For "X4" Input Range
SLOW AVG (RMS) (AVG+ or AVG−)	3-5-10-15V	6-10-20-30V	12-20-40-60V
SAG/SURGE (RMS)	3-5-10-15V	6-10-20-30V	12-20-40-60V
IMPULSE (0-pk.)	50-100-200-400V	100-200-400-800V	200-400-800-1600V

ACCURACY (for all three input voltage ranges)

Slow-Averaged Steady-State** (at 60 Hz): ±1% of reading ±1% of nominal input.

Sag/Surge** (at 60 Hz): ±1% of reading ±1% of nominal input.

Impulse: ±5% of reading ±1% of maximum impulse, calibrated with a positive-going, 10µsec, half-sinewave impulse. Typical frequency response is ±1 dB for impulse widths from 10µsec to 50 µsec, and ±6 dB for impulse widths from 0.5µsec to 800µsec, measured with half-sinewave impulses.

TIME CLOCK

Controlled by internal crystal oscillator. Crystal stability ±25 PPM (approximately ±2 seconds/day). Clock can be set to within 1 second using front panel buttons. With power switch key removed, the clock setting cannot be altered.

AUDIBLE ALARM

The Series 606 is equipped with a built-in audible alarm signal which may be disabled or placed in a 1-second signal-duration mode by means of a front panel switch.

STEADY-STATE POWER REQUIREMENTS

90 to 140 Volts RMS, 45-450 Hz, single-phase, 1.0 A. maximum. (Also DC operation from 120-170 V maximum.)

TEMPERATURE RANGE:

+50°F to +113°F (+10°C to +45°C) operating;
−40°F to +130°F (−40°C to +55°C) storage.

*Monitoring range for Sag/Surge and Average measurements is ±50% of nominal input.

†Maximum voltage for impulses having an effective duty cycle <1%.

**Based on sine wave signals.

††Surges limited to 140V RMS and impulses limited to 1000V pk. (Limits for 230V RMS nominal operation, Option 102, are 280V RMS and 2000V pk.)

OPERATION FROM DISTURBED LINES

The 606 will operate properly with line disturbances on its own power line over the entire specified measuring ranges of impulses††, sags, and surges††. It will also operate properly during interruptions of up to approximately 0.5 seconds, from the nominal line voltage.

For line interruptions exceeding 0.5 sec, the 606 will switch to internal batteries, having the capability of maintaining the clock and memories for up to four hours of power-down operation. A POWER OFF message and time are printed.

Upon restoration of power for a full ten seconds, the 606 will shift back to its normal line-powered mode. POWER ON and the time are recorded.

DIMENSIONS AND WEIGHT

Instrument is housed in a portable aluminum case with removable cover, carrying handle, and rubber feet. 11" high X 7" wide X 11½" deep (28 cm. X 18 cm. X 29 cm.) including cover. Approximately 20 pounds (9.1 kg.). An optional 19" rack mount with dust cover is also available. Shipping volume is approximately 1.6 cubic ft. (.045 cubic meter). Shipping weight is 25 pounds (11.4 kg.) approx.

STANDARD OPTIONS AND ACCESSORIES

Consult factory for detailed specifications on these and other special adaptions of the Series 606.

Option 101 (available on Model 606-3 only):
Under/Over Frequency monitoring on input channel (phase) A, with selectable thresholds of ±½, 1, and 2 Hz; ±0.25 Hz accuracy. The frequency is monitored over 1-second sampling periods. Printout indication of frequency changes exceeding selected threshold is "FREQ+" or "FREQ −".

Option 102:
Power operation either from 180 to 280 Volts RMS, 45-65 Hz, single phase, or from 90 to 140 Volts RMS, 45-450 Hz, single phase. (Switch-selectable.)

Option 103 (available only with Option 101):
Designed to add the capability of measuring and monitoring 400 Hz power lines. An internal switch changes the monitor range from 45-65 Hz to 380-450 Hz. When ordered with Options 101 and 103, the Model 606 will make all voltage and frequency measurements described above, at either 45-65 Hz or 380-450 Hz. In the latter range, the Sag/Surge measurements are made over 8 cycles; the frequency thresholds are 4, 8, and 16 Hz, and the frequency accuracy is ±2 Hz.

Option 104:
Adds to the basic 606 an additional optically isolated, 2-terminal signal-input channel that accepts a 5−12 VDC external signal. Each application of such an external signal generates a time-mark entry and identifying symbol ("#" followed by the time in hours, minutes, and seconds) on the record printout. Can be employed to enter, manually or automatically, a record of occurrences of any external event (such as an equipment malfunction) for use in subsequent analysis.

Option 105:
Adapts the Series 606 for use with Impulse Analysis Adaptors (see pages 6 and 7).

Printed Paper (P/N 102,714):
Approximately 140 feet X 2¼ inch wide rolls (2.5 inch diameter) of thermal paper. Do not substitute alternate types of paper without consulting factory.

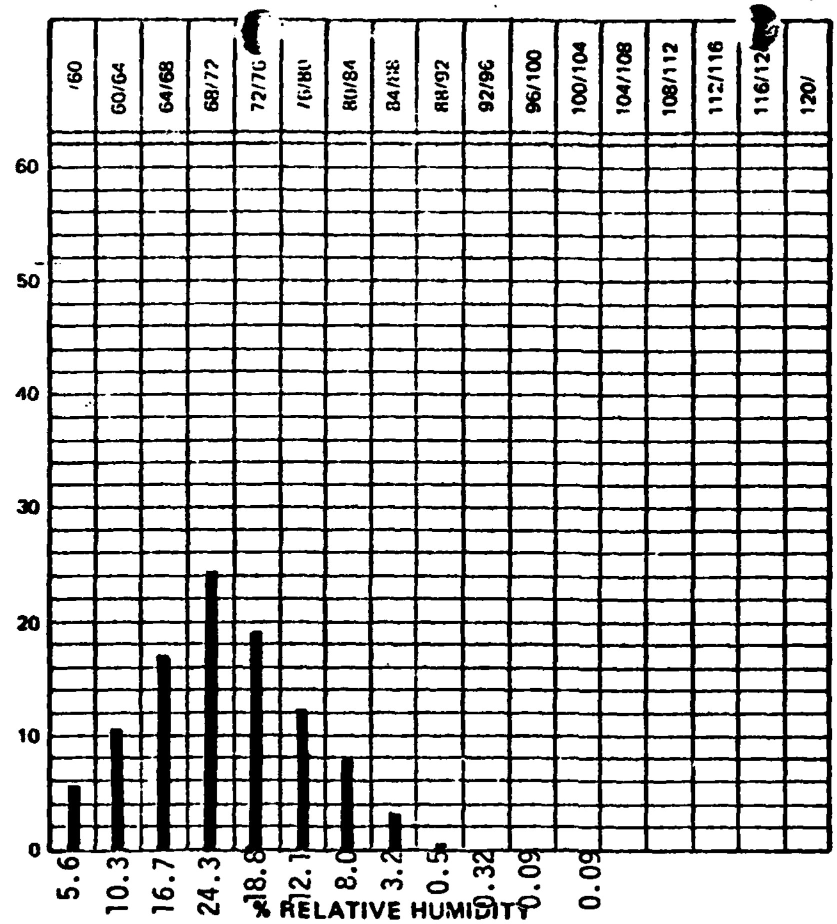
Shipping Container (P/N 103,100):
Fits any Model 606, or Model 910 (see page 10) instrument. Constructed of ⅜" plywood covered with vulcanized fiber. Lined with custom-contoured foam padding Container has steel-reinforced corners and a recessed carrying handle. Exterior dimensions, 10½" X 21" X 15" (26.7 X 53.3 X 38.1 cm.). Weight, 15 pounds (6.8 kg.).

MR15 Series Rack Mounts
19" wide X 12¼" high (48.3 X 31.1 cm) rack-mounting panels with cutouts, mounting provisions, and dust covers for the Model 606 Power Disturbance Analyzer and/or Model 910 Uninterruptible Power Source. Five combinations are available:

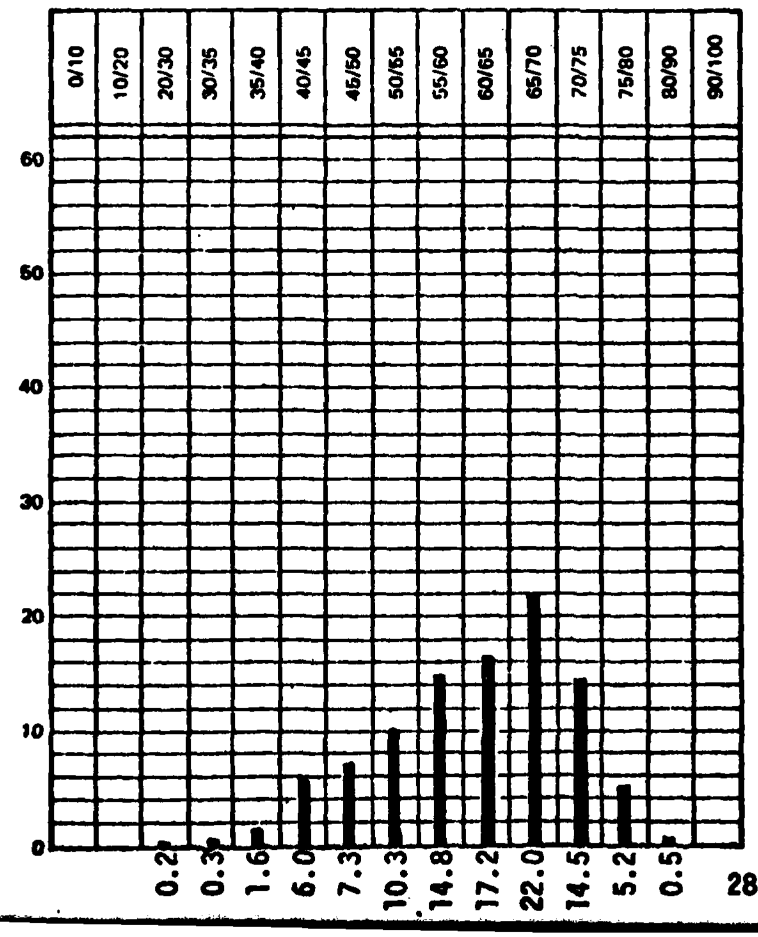
MR15 − 1 − one Model 606
− 2 − one Model 910
− 3 − two Model 606
− 4 − two Model 910
− 5 − one Model 606 and one Model 910

Figure 12. Power Line Disturbance Analyzer Specifications

TEMPERATURE °F



% RELATIVE HUMIDITY



HYGRO-THERMIC SURVEY

Ship COMPOSITE

Comp. USS COCHRANE (DDG-21)
USS BERKELEY (DDG-15)
USS HENRY B. WILSON (DDG-7)

Rec S/N -

Max T 101 °F
Min T 56 °F *
* Limited by Instrumentatic

$\bar{T}$ = 71.1 °F s = 7.2 °F

dT/dt = 28 °F/hr

Max R H 82 %
Min R H 23 %

$\overline{RH}$ = 61.2 % s = 10.1 %

dRM/dt = 20 %/hr

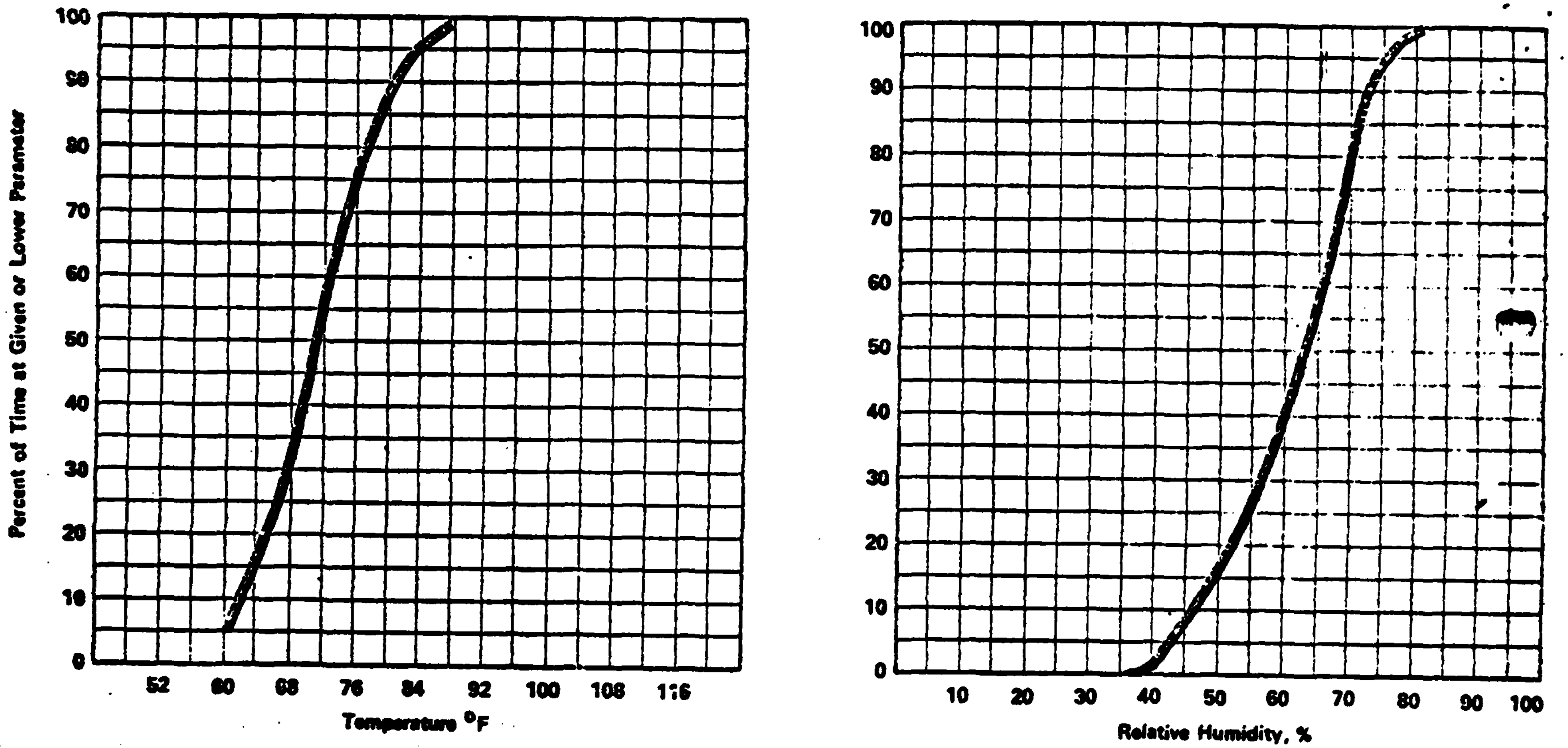
Elapsed Time 4422 Hrs (Total)

Geographical Location
Temperate Zone (PACIFIC)

Survey Date APR 78 - SEP 78

Major Equipment

Figure 13.
Hygro-Thermic Survey



TEMPERATURE & RELATIVE HUMIDITY DISTRIBUTIONS

MAX:	**MIN:**		
T = 101 °F	T = 56 °F	$\overline{T}$ = 71.1 °F	s = 7.2 °F
RH = 82 %	RH = 23 %	$\overline{RH}$ = 61.2 %	s = 10.1 %
dT/dt = 28 °F/hr			
dH/dt = 20 %/hr			

SHIP: COMPOSITE
HULL NUMBER: DDG CLASS
DATE: APR 78 - SEP 78
GEOGRAPHICAL LOCATION: TEMPERATE ZONE
MAJOR EQUIPMENT: TARTAR WEAPON
ZONE: SPACES

Figure 14.
Temperature and Relative Humidity Distributions

RELATIVE HUMIDITY VS TEMPERATURE, TEMPERATE ZONE

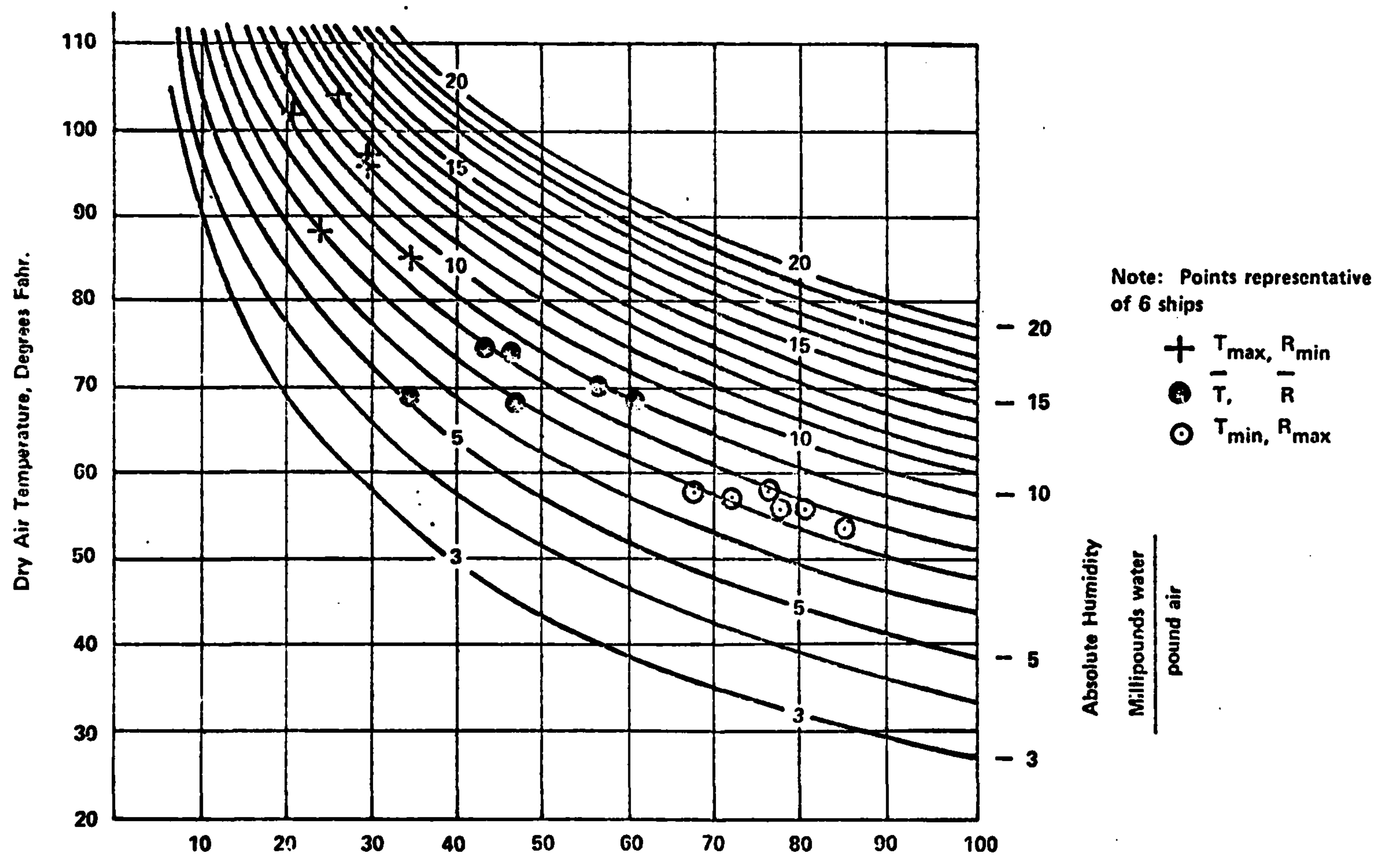
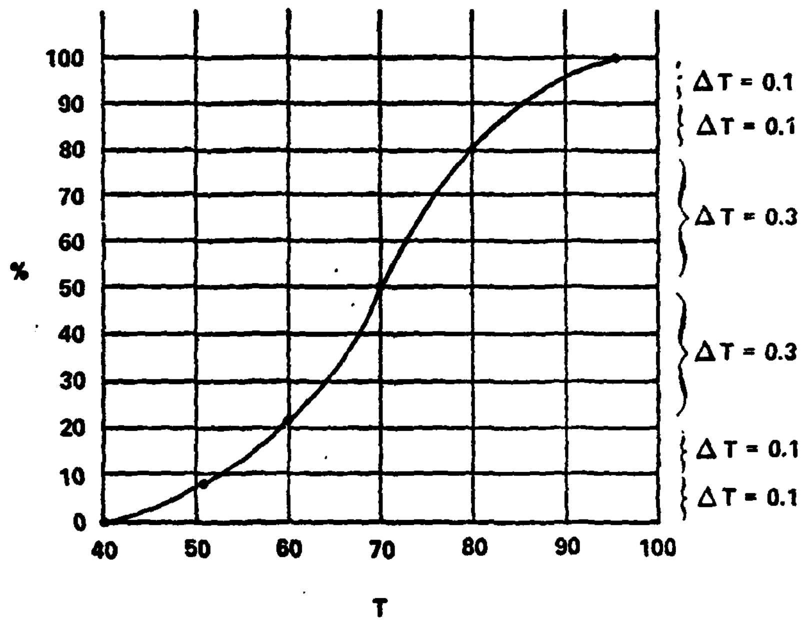


Figure 15.

APPLICATION TO T/RH TESTING



- TOTAL TEST TIME = X
  (DETERMINED FROM MTBF RQMT)

<u>ACCEPTANCE TEST</u>

- INCREMENTAL TEST TIMES:

0.1X	40 - 50°F	60 - 80%
0.1X	50 - 60°F	45 - 85%
0.3X	60 - 70°F	40 - 65%
0.3X	70 - 80°F	30 - 80%
0.1X	80 - 90°F	30 - 80%
0.1X	90 - 100°F	30 - 50%

(CHANGE AT MEASURED MAX RATE)

Figure 16

SCHEDULE

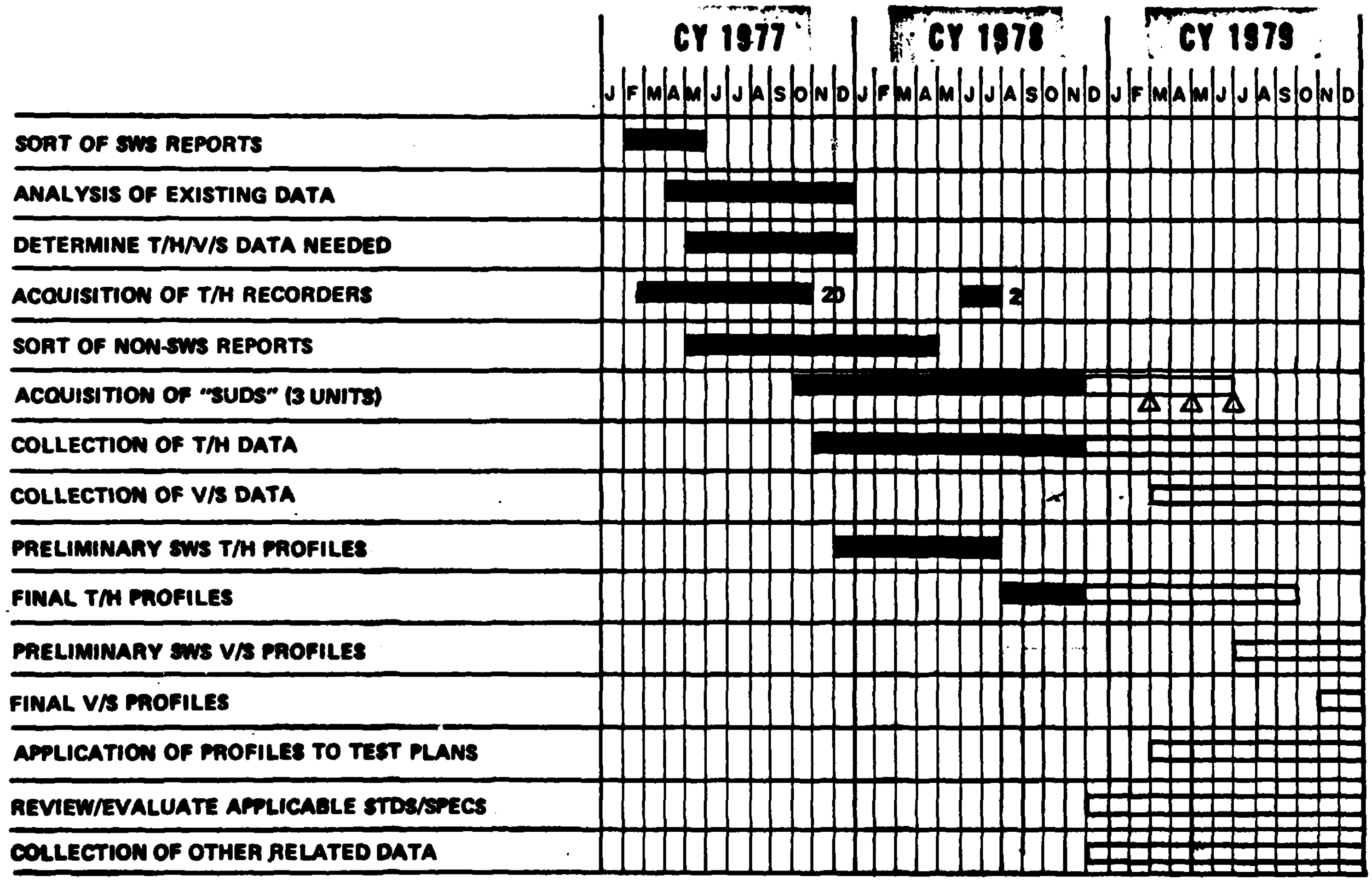


Figure 17.

DATE

ILME